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Science 30
Course Outcomes
Resource Development Draft

August 2002

The Resource Development Draft incorporates revisions based on the November 1999 and May 2000 validation drafts. Further minor adjustments to the course outcomes may be made following field testing in September–December 2005.

Unit Organization

In Grades 7–9, five units of study are outlined at each grade level. At grades 10–12, four units of study are outlined for each grade level. Each unit includes the following components.

Unit Overview

Each unit of study begins with an overview that introduces the contents of the unit and suggests an approach to its development.

Focusing Questions

These questions frame a context for introducing the unit and suggest a focus for investigative activities and application of ideas by students.

Key Concepts

Key concepts identify major ideas to be developed in each unit. Some of the key concepts may be addressed in additional units at the same grade/course level, as well as at other grade/course levels. The intended scope of treatment of these concepts is indicated by the learner outcomes.

Outcomes

Two levels of outcomes are provided in the draft program and courses of study:

- General Outcomes: These are the major outcomes for each unit. For STS and knowledge, the outcomes are combined and unique to each unit. For skills and attitudes, the outcomes are common to all units.
- Specific Outcomes: These are detailed outcomes that flesh out the scope of each unit. They are shown in bulleted form.

Examples

Many of the outcomes are supported by examples. The examples **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed. Illustrative examples are written in *italics* and separated from the outcomes by being placed in parentheses.

Unit Emphases

Each unit of study in secondary science begins with an overview and a set of focusing questions that identify a context for study. In defining the context, one of the following areas of emphasis is identified for each unit.

- *Nature of Science* emphasis: In these units student attention is focused on the processes by which scientific knowledge is developed and tested, and on the nature of the scientific knowledge itself. Skills emphasized in these units are the skills of scientific inquiry.
- *Science and Technology* emphasis: In these units students seek solutions to practical problems by developing and testing prototypes, products and techniques to meet a given need. The skills emphasized are those of problem solving, in combination with the skills of scientific inquiry.
- *Social and Environmental Contexts* emphasis: In these units student attention is focused on issues and decisions relating to how science and technology are applied. Skill emphasis is on the use of research and inquiry skills to inform decisions; students seek and analyze information and consider a variety of perspectives.

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Unit A: Living Systems Respond to their Environment *(Nature of Science emphasis)*

Overview: The human body continually interacts with the external environment. In this unit, students learn that the circulatory system assists in this interaction between the blood cells and the external environment and, with the immune system, defends the body against disease-causing organisms. Students apply the principles of heredity and molecular genetics to explain human disorders and to assess the risks and benefits of genetic technologies.

Focusing Questions: What is the structure and function of the human circulatory system in maintaining human health? What are the defence mechanisms of the human body? How have the principles of genetics been applied to treat genetic diseases, and what are the related ethical issues?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- ☆ structure and function of the circulatory system
- ☆ cellular components of human blood tissue, and the role of blood
- ☆ defense mechanisms and immunity to disease organisms
- ☆ functioning of cellular and noncellular components of the immune system
- ☆ principles of genetics
- ☆ genetic technology and resulting ethical issues

STS and Knowledge Outcomes

Students will:

1. Analyze how the circulatory system facilitates interaction between the human body's blood cells and the external environment, and investigate cardiovascular health
   - describe the structure and function of the circulatory system, including the heart, arteries, arterioles, venules, veins and capillaries, and the path of blood circulation
   - describe and investigate the structure and function of the vessels and chambers of the mammalian heart, i.e., ventricles, atria, aorta, vena cava, pulmonary arteries
   - explain, in general terms, the functions of the main components of human blood tissue, including red and white blood cells, platelets, and plasma
   - describe, in general terms, the role of blood as a transporting medium for nutrients, hormones, gases, wastes, toxins, and medications
   - investigate and describe how harmful substances in the environment enter the circulatory system and may have an adverse influence on health *(e.g., mosquito-borne parasites or bacteria through breaks in the skin)*
   - explain and investigate the relationship between regular exercise, lifestyle, diet, gender and cardiovascular health *(e.g., normal blood pressure, heart rate and cholesterol levels)*.

2. Analyze the defence mechanisms used by the human body to protect itself from disease-causing organisms found in the external environment
   - describe, in general terms, the functions of the various mechanisms, including skin, body secretions and stomach acid, that prevent disease-causing organisms from entering body tissues
   - describe, in general terms, how immunity to disease-causing organisms develops, how the human immune system responds to a foreign antigen and the roles of macrophages, helper T cells, B cells, killer T cells, suppressor T cells, memory T cells and antibodies

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- explain the interrelationship of autoimmune diseases and the human immune system *(e.g., multiple sclerosis, arthritis)*
- analyze how vaccines defend against disease-causing viruses and bacteria
- describe how improvements to sanitation, personal hygiene and the availability of potable water have greatly reduced the incidence of communicable diseases; and discuss the ongoing need for vigilance and research into modes of transmission *(e.g., tuberculosis, typhoid, cholera, gastrointestinal diseases).*

3. Apply the principles of heredity and molecular genetics to explain how human diseases can arise from inherited traits, the risks and benefits of genetic technology, and the need for ethical considerations in the application of scientific knowledge
   - trace the development of plant and animal breeding techniques from Mendel's work on inheritance, to the discovery of the molecular structure of DNA by Watson and Crick, to recombinant DNA technology
   - explain the inheritance of single traits, using the unit of inheritance (gene), segregation, and dominance/recessiveness *(e.g., construct Punnet squares)*
   - describe the structure of DNA by:
     - identifying the structure of DNA as a double helix
     - listing the essential building block components of DNA as nucleotides
     - identifying the base pairings between the strands of the double helix
   - explain the need for a replication mechanism for DNA
   - describe the function of DNA by:
     - explaining that proteins are composed of amino acids
     - describing how an amino acid sequence is determined by the sequence of DNA triplet codes; i.e., use a table of DNA triplets matched with amino acids to construct an amino acid chain from a strand of DNA
   - describe the role of proteins in the human body; i.e., regulate chemical reactions in the cell, control passage of matter in and out of the cell, and provide the shape and structure of the cell membrane
   - describe how mutations in DNA affect the proteins produced
   - describe the effects of mutations resulting in human diseases *(e.g., hemophilia, Huntington's, cystic fibrosis, sickle-cell anemia)*
   - describe, in general terms, gene therapy *(e.g., the use of vectors in cystic fibrosis)*
   - describe the development of resistance in bacteria and viruses, based on the concepts of mutation and natural selection
   - assess the risk and benefits of genetic technology and the need for ethical considerations *(e.g., genetically-engineered plants to resist bacteria, access to genetic screening).*

Skill Outcomes *(focus on scientific inquiry)*

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- define and delimit problems to facilitate investigation *(e.g., what is the interrelationship between environment and genetics in diseases such as diabetes)*
- design an experiment, identifying manipulated, responding and controlled variables *(e.g., design an experiment to determine the effect of exercise on blood pressure)*

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- state a prediction and a hypothesis based on available evidence and background information *(e.g., investigate the relationship between chance and inheritance)*
- develop appropriate sampling procedures *(e.g., investigate the presence of single factor, inherited trait in a pedigree).*

Performing and Recording

Students will:

Conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information

- implement appropriate sampling procedures *(e.g., conduct an investigation into the incidence of mosquito-borne diseases in Canada's biogeographic regions)*
- carry out procedures, controlling the major variables, and adapt or extend those procedures where required *(e.g., perform an experiment to test the effect of simulated stomach acid on bacterial growth)*
- use instruments effectively and accurately for collecting data *(e.g., use computer software or video programs to view the internal structure of the heart and to view blood flow; observe the effects of valves on venous blood flow; observe prepared slides or electronic images of human blood, using different fields of view)*
- estimate quantities *(e.g., determine the number of heartbeats per year or the volume of blood flow circulated in a year)*
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data *(e.g., collect data on the relationship of lifestyle factors such as diet, exercise and smoking on heart attack rates).*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible explanations

- analyze and discuss limitations of a given classification system, and identify alternative ways of classifying to accommodate anomalies *(e.g., investigate various ways the human body protects itself from diseases)*
- compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots *(e.g., relate the blood flow, structures and function of the mammalian heart in a flow chart; simulate an immune response or the body's production of proteins, using models; trace the development of theories about human circulation and disease transmission)*
- identify a line of best fit on a scatterplot, and interpolate or extrapolate based on the line of best fit *(e.g., plot the relationship between heart rate and size of organism)*
- apply and assess alternative theoretical models for interpreting knowledge in a given field *(e.g., evaluate the hypothesis that blood flow can be explained on the basis of tidal forces; or that AIDS is not caused by the HIV virus)*
- provide a statement that addresses the problem or answers the question investigated, in light of the link between data and the conclusion *(e.g., consider the effect of antibacterial soaps on the characteristics of bacterial populations)*
- explain how data support or refute the hypothesis or prediction *(e.g., use a commercially-available simulation to compare a healthy person, an athlete and a person with cardiac disease in terms of oxygen demand, cardiac output and vessel blockage)*

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- identify new questions or problems that arise from what was learned *(e.g., "Why do some individuals refuse to use vaccinations?" "Why is the incidence of tuberculosis rising?")*
- identify and evaluate potential applications of findings *(e.g., relate genetic engineering and its applications with health and agriculture, "What are the implications of introducing genetically altered foods into the food chain?").*

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., select and use multimedia capabilities for presentation; present findings on the roles of various factors, such as lifestyle and genetics, influencing blood pressure; draw and label a dissected mammalian heart to show structure and function as they relate to blood flow; relate sources of mutagens found in the environment with rate of mutation)*
- synthesize information from multiple sources or from complex and lengthy texts, and make inferences based on this information *(e.g., record relevant data for acknowledging sources of information, and cite sources correctly; use integrated software effectively and efficiently to reproduce work that incorporates data, graphics and text; research mutagens found in daily life, and investigate if there is an "acceptable level" of a mutagen in the environment)*
- evaluate individual and group processes used in planning, problem solving and decision making, and completing a task *(e.g., devise an experimental procedure to investigate genetically-engineered canola and, as a class, evaluate the procedure).*

Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not *(e.g., consider the social and cultural contexts in which a theory developed; recognize the usefulness of having skills in mathematics and problem solving; appreciate how scientific problem solving and the development of new technologies are related).*

Interest in Science

Students will be encouraged to:

- show a continuing and more informed curiosity and interest in science and science-related issues *(e.g., research the answers to their own questions; explore and use a variety of methods and resources to increase their own knowledge and skills; be critical and constructive when considering new theories and techniques)*
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research *(e.g., use scientific vocabulary and principles in everyday discussions)*

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- consider further studies and careers in science- and technology-related fields *(e.g., maintain interest or pursue further studies in science; explore where further science- and technology-related studies in biotechnology or the health field can be pursued).*

Scientific Attitudes

Students will be encouraged to:

- evaluate evidence confidently, and consider alternative perspectives, ideas and explanations *(e.g., insist on evidence before accepting a new idea or explanation; critically evaluate inferences and conclusions, being cognizant of the many variables involved in experimentation)*
- use factual information and rational explanations when analyzing and evaluating *(e.g., insist that the critical assumptions behind any line of reasoning be made explicit, so that the validity of the position taken can be judged)*
- value the processes for drawing conclusions *(e.g., ask questions and do research to ensure they understand; recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen; expend the effort and time needed to make valid inferences; seek new models, explanations and theories when confronted with discrepant events).*

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *(e.g., work willingly and cooperatively with classmates to complete group assignments; provide the same attention and energy to the group's product as they would to a personal assignment).*

Safety

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations *(e.g., consider safety a positive limiting factor in scientific and technological endeavours; assume responsibility for the safety of all those who share a common working environment, by cleaning up after an activity and disposing of materials in a safe place).*

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Unit B: Chemistry and the Environment *(Social and Environmental Contexts emphasis)*

Overview: Society is becoming increasingly reliant upon chemical substances in maintaining quality of life. However, these chemicals and their by-products can also adversely affect the environment and living systems. Knowledge of chemistry is essential to fully understand the benefits and risks of chemicals to humankind, and in monitoring the emission of these substances into the environment. In this unit, students examine the impact of acids and bases, organic compounds and air pollutants, on aquatic and terrestrial ecosystems.

Focusing Questions: What are some of the important effects of acids and bases, and synthetic organic compounds, on the environment and living systems? What are the chemical principles and perspectives involved in assessing the technologies designed to produce and reduce the release of these compounds into the environment? How do we look beyond a "technological fix" in deciding how to best meet human needs and yet sustain the environment?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- ☆ definition of acids and bases
- ☆ pH and hydronium ion concentration
- ☆ stoichiometry and titration of strong (monoprotic) acids and bases
- ☆ buffers and buffering capacity
- ☆ changes to biotic and abiotic environment by acid deposition
- ☆ sources and environmental impact of SO_x, NO_x, acid rain and photochemical smog
- ☆ sources, uses and environmental effects of selected hydrocarbons (3-carbon limit)
- ☆ biomagnification, lethal dose and persistence
- ☆ risks and benefits of reducing environmental damage due to chemical processes

STS and Knowledge Outcomes

Students will:

1. Analyze the sources and the effect of acids and bases on the biotic and abiotic components of the environment
   - identify and explain how human activities and natural events contribute to acid deposition in the environment
   - outline the chemical reactions that produce air pollutants, such as sulfur dioxide, nitrogen dioxide and carbon dioxide, that in turn produce "acid rain" *(e.g., combustion reactions)*
   - describe the technologies used to reduce the incidence of acid rain
   - describe, in general terms, the uses of acids and bases in industry *(e.g., hydrochloric acid [used to extract metals from ores], sulphuric acid [used to make fertilizers, paints, plastics, dyes and detergents], and sodium hydroxide [used to make drain and oven cleaners, soaps])*
   - define acids and bases in terms of proton donors and acceptors, respectively
   - use diagnostic tests to differentiate among acids, bases, neutral and ionic solutions, neutral molecular compounds, and strong and weak acids
   - measure the pH of common substances, using a pH meter and/or pH paper and indicators
   - predict the concentration of strong (monoprotic) acids and bases, using stoichiometry and titration data
   - calculate pH from hydronium ion concentration, and hydronium ion concentration from pH
   - explain, qualitatively, how buffers maintain a relatively constant pH when a small amount of acid or base is added to an aqueous system

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- explain what is meant by the buffering capacity of soil or bedrock
- explain the importance of maintaining a relatively constant pH in a living system *(e.g., the Arctic herb Artemisia tilesii has evolved to resist acidic moisture by extracting calcium from the soil and pumping it to leaves, role of bicarbonate ion in maintaining the pH of blood)*
- describe changes to the biotic and abiotic components of the environment caused by acid deposition *(e.g., lowered pH in water systems; accelerated corrosion; metal leaching from bedrock; uptake of leached metals by plants, retarding growth; and physiological effects on living organisms)*. [Prerequisite: Science 20 Unit B].

2. Analyze the sources and the effect of organic compounds on the environment
   - identify and explain how human activities and natural events contribute to the production of photochemical smog, depletion of the ozone layer by CFCs and increased concentrations of organic compounds in the environment
   - list the sources of organic compounds commonly considered to be water pollutants *(e.g., hydrocarbons, organic matter, dioxins and furans, pesticides and herbicides)*
   - identify potentially toxic compounds produced as a by-product of chemical processes *(e.g., No_x, dioxins and furans)*
   - identify and name simple halogenated hydrocarbons, alcohols, carboxylic acids and esters containing up to three carbon atoms from functional groups; and describe their common uses *(e.g., chlorofluorocarbons (CFCs) as refrigerants, as propellants and in the manufacture of plastic foam products; polychlorinated biphenyls (PCBs) as electrical insulators; ethanol as a solvent and a gasoline additive; ethanoic acid as vinegar; ethylethanoate as nail polish remover)*
   - classify hazards posed by halogenated hydrocarbons
   - interpret information describing the effects of hazardous chemicals on biological systems *(e.g., lethal dose (LD, LD_{50}), biomagnification and persistence)*
   - explain how the introduction of environmental contaminants affects living systems globally *(e.g., DDT, CFCs, $SO_2(g)$, $CO_2(g)$)*.

3. Analyze, from a variety of perspectives, the risks and benefits of using chemical processes in meeting human needs and reducing the impact on the environment
   - describe the risks and benefits of the methods being used to reduce the incidence of acid rain and photochemical smog *(e.g., reducing sulfur content in fuels, catalytic converters in cars, smokestack scrubbers)*
   - explain the meaning of "technological fix", and explain the need for broader considerations in reducing the environmental impact of the by-products of chemical processes
   - identify and analyze alternatives to the use of chemical technologies *(e.g., bioremediation for contaminated soil, biological controls for pests, and/or alternatives that are more efficient, target specific, effective, biodegradable)*.

Skill Outcomes *(focus on applying science to inform decision-making processes)*

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- identify questions to investigate that arise from practical problems and issues *(e.g., investigate the buffering capacity of local soil or pond samples, or alternatives to use of pesticides or herbicides)*

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- design an experiment, and identify specific variables *(e.g., differentiate among acids, bases, neutral ionic and molecular solutions)*
- state a prediction and a hypothesis based on available evidence and background information *(e.g., predict the impact of acid rain or synthetic organic compounds on an aquatic or terrestrial ecosystem respectively; hypothesize about seasonal variations in water quality in the community)*
- evaluate and select appropriate instruments for problem solving, inquiry and decision making *(e.g., decide which would be better to use: pH meter, pH paper or indicator).*

Performing and Recording

Students will:

Conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information

- implement appropriate sampling procedures *(e.g., when measuring soil and water quality in terrestrial or aquatic ecosystems)*
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data *(e.g., measure the pH of water using computer-based probes and/or a graphing calculator)*
- select and use apparatus and materials safely *(e.g., use a pH meter for collecting data in the study of an aquatic ecosystem; use titration to determine the concentration of an acid or a base)*
- use library and electronic research tools to collect information on a given topic *(e.g., debate the issue: "Protecting the environment should have priority over economic interests"; use current, reliable information sources from around the world on technologies and methods used to reduce pollution, acid rain, release of organic compounds; demonstrate proficiency in uploading and downloading text, image, audio and video files)*
- select and integrate information from various print and electronic sources *(e.g., create multiple-link documents appropriate to the content of the particular topic; search government publications and gather relevant information initiatives designed to reduce the impact of chemical technologies on the environment).*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible explanations

- compile and display evidence and information, by hand or using technology, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots *(e.g., manipulate and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases or spreadsheets; present statistical data in diagrams, tables and graphs as part of a brief for a public hearing on a proposed chemical industry in an ecologically sensitive area)*
- evaluate the relevance, reliability and adequacy of data and data collection methods *(e.g., identify sources of error in environmental monitoring)*
- identify new questions or problems that arise from what was learned *(e.g., "What is the relationship between weather and patterns of acid deposition?")*
- identify and evaluate potential applications of findings *(e.g., relate patterns of carbon dioxide emissions to global temperatures).*

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Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions; and receive, interpret, understand, support and respond to the ideas of others *(e.g., use appropriate communication technology to elicit feedback from others; participate in a variety of electronic group formats; prepare a visual display, explaining initiatives taken by industry to protect the environment)*
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., use advanced menu features within a word processor to accomplish a task to insert tables, graphs, text and graphics for tracing biomagnification of a pesticide via food webs and various trophic levels in an ecosystem)*
- synthesize information from multiple sources or from complex and lengthy texts, and make inferences based on this information *(e.g., record relevant data for acknowledging sources of information, and cite sources correctly; use integrated software effectively and efficiently to reproduce work that incorporates data, graphics and text)*
- identify multiple perspectives that influence a science-related decision or issue *(e.g., consult a wide variety of sources that reflect varied viewpoints on particular topics, such as the use of DDT in countries where malaria is a major cause of death)*
- develop, present and defend a position or course of action, based on findings *(e.g., solve problems and create protocols for transporting acidic and caustic materials through populated areas)*
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., develop, seek feedback, test and review, make revisions, and implement a plan for testing samples).*

Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- appreciate that the applications of science and technology can raise ethical dilemmas *(e.g., use a multi-perspective approach, considering scientific, technological, economic, cultural, political and environmental factors, when formulating conclusions, solving problems or making decisions on an environmental issue; carefully research and openly discuss ethical dilemmas associated with the applications of science and technology)*
- value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds *(e.g., recognize the contribution of science and technology to the progress of civilizations; recognize that western approaches to science are not the only ways of viewing the universe; consider the research of both men and women).*

Interest in Science

Students will be encouraged to:

- show a continuing and more informed curiosity and interest in science and science-related issues *(e.g., explore and use a variety of methods and resources to increase their own knowledge and skills; demonstrate an interest in science and technology topics not directly related to their formal studies)*

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- consider further studies and careers in science- and technology-related fields *(e.g., maintain interest or pursue further studies in science).*

Scientific Attitudes

Students will be encouraged to:

- evaluate evidence confidently, and consider alternative perspectives, ideas and explanations *(e.g., insist on evidence before accepting a new idea or explanation; critically assess their opinion of the value of science and its applications; criticize arguments in which evidence, explanations or positions do not reflect the diversity of perspectives that exist)*
- use factual information and rational explanations when analyzing and evaluating *(e.g., criticize arguments based on the faulty, incomplete or misleading use of numbers; insist that the critical assumptions behind any line of reasoning be made explicit, so that the validity of the position taken can be judged).*

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *(e.g., be attentive when others speak; seek the point of view of others, and consider a multitude of perspectives).*

Stewardship and Ethical Behaviour

Students will be encouraged to:

- have a sense of personal and shared responsibility for maintaining a sustainable environment *(e.g., assume part of the collective responsibility for the impact of humans on the environment; participate in community activities related to the preservation and judicious use of the environment and its resources; encourage their peers or members of their community to participate in a project related to sustainability)*
- project the personal, social and environmental consequences of proposed action *(e.g., consider all perspectives when addressing issues, weighing scientific, technological and ecological factors; discuss both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans)*
- want to take action for maintaining a sustainable environment *(e.g., participate in the social and political systems that influence environmental policy in their community; willingly promote actions that are not injurious to the environment; make personal decisions based on responsibility toward less privileged parts of the global community and toward future generations; be critical-minded regarding the short- and long-term consequences of sustainability).*

Safety

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations *(e.g., criticize a procedure, a design or materials that are not safe or that could have a negative impact on the environment; consider safety a positive limiting factor in scientific and technological endeavours)*
- be aware of the direct and indirect consequences of their actions *(e.g., carefully manipulate materials, being cognizant of the risks and consequences of their actions).*

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Unit C: Electromagnetic Energy *(Science and Technology emphasis)*

Overview: Electrical energy transmission and transformation technologies, based on field theory and on an understanding of electromagnetic radiation (emr), play an important role in meeting human needs. These technologies are also useful in furthering our understanding of the universe. In this unit, students investigate the functioning of these technologies, the principles of field theory and the properties of emr.

Focusing Questions: How can field theory be used to explain the function of electrical devices in the home and the workplace? How are the specific characteristics of the electromagnetic spectrum applied to communication and remote sensing technologies? How do imaging technologies reveal the structure and the history of the universe and shape our understanding of the universe?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- ☆ devices based on electrical and magnetic fields (electric motors, generators and transformers)
- ☆ basic characteristics of field theory for the comparison of gravitational, electric and magnetic fields
- ☆ calculating electric and gravitational field strength, electrical energy and power
- ☆ properties of emr spectrum, and effects on living tissue
- ☆ principles of communication and remote sensing technology
- ☆ risks and benefits of electromagnetic radiation technology
- ☆ technologies used to study the structure and history of the universe

STS and Knowledge Outcomes

Students will:

1. Investigate and describe the technologies used in daily life and used to study the universe, that are based upon the applications of field theory and properties of electromagnetic radiation (emr)
   - describe, in general terms, examples of technological devices based on current electricity, and describe their impact on daily life *(e.g., light bulbs electrical devices, and electromagnets in the home, workplace and industry)*
   - describe, in general terms, examples of technological devices based on electric and magnetic fields, and describe their impact on daily life *(e.g., telephone, CD player, photocopier, electrostatic filters and scrubbers, cellular phone)*
   - identify examples of technologies that apply electromagnetic radiation to solve modern communication, medical and industrial problems *(e.g., use of radio waves, microwaves, fibre optics and infrared light in communications; remote sensing technologies, including telescopes, space probes and satellites, use of UV radiation to kill bacteria, diagnostic MRI and X-rays).*

2. Explain the field theory, and analyze the applications of field theory in technologies used to produce, transmit and transform electrical energy
   - investigate and describe the effect of a conductor moving through a magnetic field to induce an electrical current
   - define a field as space around a mass, electric charge or a magnet, that causes another mass, electric charge or a magnet introduced to this region to experience a force
   - investigate and compare the interaction between static electric charges with the interaction between magnetic poles and between two masses at a distance
   - compare the basic characteristics of all vector fields, including gravitational, electric and magnetic; source, direction and strength of field; as determined by a test object

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- calculate gravitational and electric field strength at a given distance from a source, using the following equations, respectively: $|\vec{g}| = Gm/r^2$ and $|\vec{E}| = kq_1/r^2$
- describe the relationships among power, current, voltage and resistance for series and parallel circuits; i.e., $V=IR$, $P=VI$ and $P=I^2R$, given two variables and three resistors
- determine electrical energy in kilowatt-hour (kWh) and joules, using the formula for electrical energy: $E_e = Pt$ $(P=VI)$
- distinguish between alternating and direct current, in terms of electron flow and electric field
- explain the operation of a transformer, in terms of the relationship among current, voltage and the number of turns in the primary and secondary coils; and calculate any of the variables in the relationship $N_p/N_s=V_p/V_s=I_s/I_p$
- describe the advantage of alternating current over direct current for transmitting and using electrical energy
- describe, in terms of design and electrical energy, the functioning of safety technologies *(e.g., circuit fuses and breakers, polarized plug and ground wiring)*
- compare the general design and function of an electric motor and generator.

3. Describe the specific characteristics of the electromagnetic spectrum, and describe the applications of these properties in communication systems and remote sensing technologies used to study the universe
   - describe the range of electromagnetic spectrum from long, low frequency radio waves through microwaves, infrared, visible light and ultraviolet to very short, high frequency X-rays and gamma rays
   - compare, to each other, the various constituents of electromagnetic spectrum on the basis of source, frequency, wavelength, energy and the effect on living tissue *(e.g., UV radiation on human skin and photosynthetic organisms; gamma radiation on living cells; visible light on plants, phytoplankton and humans; artificial illumination on the growth of plants)*
   - investigate and describe, qualitatively, the phenomena of reflection, refraction, diffraction and polarization of visible light
   - compare the characteristics of radiation from any region of the electromagnetic spectrum with those of visible light *(e.g., reflection, refraction, diffractions, speed, penetrability)*
   - investigate and predict the effects of changing one, or a combination, of variables in the relationship $v = f\lambda$
   - explain, in general terms, the design of telescopes used to gather information about the universe by collecting as much emr as possible; i.e., reflecting and refracting optical and radio telescopes
   - explain that nuclear fusion in the Sun produces a wide spectrum of electromagnetic radiation
   - describe how Earth's atmosphere absorbs certain frequencies of solar emr extending from Science 10, Unit D *(e.g., role of ozone in filtering UV radiation, role of water vapour and gases in absorbing ambient solar radiation)*
   - describe in general terms, how the spectroscope can be used to determine the composition of incandescent objects or substances, and the conditions necessary to produce line emission and absorption spectra, in terms of light source and temperature
   - describe how spectroscopes, used to analyze the distribution of energy in a star's spectrum, can be used to estimate the surface temperature of the star; and the use of Doppler shift technology to measure the speed of distant stars, in providing evidence that the universe is expanding
   - describe, in general terms, the evolution of stars and the existence of black holes, white dwarf and neutron stars
   - explain in general terms, how cosmic rays detection technologies have advanced scientific knowledge of our universe and the structure of matter

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- compare beliefs from a variety of cultures with the current scientific theories on the origin and evolution of the universe.

Skill Outcomes *(focus on problem solving)*

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- identify questions to investigate that arise from practical problems and issues *(e.g., "What is the public concern regarding exposure to electromagnetic radiation from video terminals, cellular telephones and other devices?")*
- design an experiment, and identify specific variables *(e.g., investigate reflection, refraction or polarization of visible light, the effect on the motion of a conductor moving in a magnetic field by variables such as charge, velocity, and magnetic field strength)*
- state a prediction and a hypothesis based on available evidence and background information *(e.g., state the qualitative relationship among the refractive index, the angle of incidence and total internal reflection)*
- formulate operational definitions of major variables *(e.g., field, resistance, current and voltage)*
- evaluate and select appropriate instruments for problem solving, inquiring and decision making *(e.g., use a prism, diffraction grating, light meter, a spectroscope, voltmeter, or ammeter appropriately).*

Performing and Recording

Students will:

Conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information

- use instruments effectively and accurately for collecting data *(e.g., collect data on electricity with a voltmeter or an ammeter; use a spectrometer, or prism or diffraction grating to observe a continuous spectrum of sunlight; observe the colour changes of an incandescent object as temperature is gradually increased)*
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data *(e.g., draw diagrams to represent gravitational, electric and magnetic fields, using field lines; represent nuclear change occurring in the Sun with the equation:* ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{2}^{3}He + {}_{0}^{1}n$*).*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible explanations

- compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots *(e.g., illustrate the difference between amplitude and frequency modulated radio waves; draw diagrams and illustrate polarization, reflection and refraction of visible light; create data tables for investigations into reflection or refraction)*

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- evaluate the relevance, reliability and adequacy of data and data collection methods *(e.g., assess the reliability and validity of electronically-accessed information on exposure to electromagnetic radiation from video terminals, cellular telephones and other devices)*
- identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information *(e.g., assess the authority, reliability and validity of electronically-accessed information on exposure to electromagnetic radiation from video terminals; identify and analyze a variety of factors that affect the authenticity of information)*
- identify and correct practical problems in the way a technological device or system functions *(e.g., discuss how lenses and/or laser surgery are used to correct vision problems)*
- construct and test a prototype of a device or system, and troubleshoot problems as they arise *(e.g., construct a simple electric generator or motor)*
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan *(e.g., propose a plan to protect humans from exposure to electromagnetic radiation emitted by devices such as 5 W radio telephones, lap top computers, video terminals)*
- evaluate a personally designed and constructed device on the basis of criteria they have developed themselves *(e.g., evaluate a self-constructed simple electric generator or motor in terms of design, ruggedness and ability to perform a specific function)*
- identify new questions or problems that arise from what was learned *(e.g., "What technological measures are being taken to reduce exposure to electromagnetic radiation?")*
- identify and evaluate potential applications of findings *(e.g., "What is the relationship between polarization of light and the ability of insects to use this property to navigate?"; "How are emission and absorption spectra applied?").*

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions; and receive, interpret, understand, support and respond to the ideas of others *(e.g., use appropriate communication technology to elicit information on recent advances in the study of the universe; participate in a variety of electronic group formats, when developing criteria to assess telescopes designed to study the universe)*
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., select and use multimedia capabilities for presenting research on the effect of having high voltage power lines or a communications tower located in a community)*
- identify multiple perspectives that influence a science-related decision or issue *(e.g., assess the value to society of studying the structure and the history of the universe and the expense of building telescopes, such as the Hubble, or sending space probes)*
- develop, present and defend a position or course of action, based on findings *(e.g., take a position in support of or against the location of high voltage power lines or a communications tower in their local community)*
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., develop a plan to construct a simple electric generator or motor, seek feedback, test and review the plan, make revisions, and implement the plan).*

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Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not *(e.g., appreciate how scientific problem solving and the development of new technologies are related; recognize the contribution of science and technology to the progress of civilizations)*
- value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds *(e.g., recognize the contribution of science and technology to the progress of civilizations; consider the research of both men and women [Canadians Dr. Helen Hogg and Ian Shelton]).*

Interest in Science

Students will be encouraged to:

- consider further studies and careers in science- and technology-related fields *(e.g., recognize that part-time jobs require science- and technology-related knowledge and skills; explore where further science- and technology-related studies, such as medical X-ray technology or astronomy, can be pursued).*

Scientific Attitudes

Students will be encouraged to:

- evaluate evidence confidently, and consider alternative perspectives, ideas and explanations *(e.g., critically evaluate inferences and conclusions, being cognizant of the many variables involved in experimentation; critically assess their opinion of the value of science and its applications; criticize arguments in which evidence, explanations or positions do not reflect the diversity of perspectives that exist)*
- use factual information and rational explanations when analyzing and evaluating *(e.g., criticize arguments based on the faulty, incomplete or misleading use of numbers; insist that the critical assumptions behind any line of reasoning be made explicit, so that the validity of the position taken can be judged).*

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *(e.g., explore personal perspectives, attitudes and beliefs toward the use of technology, when taking a position in support of or against the location of high voltage power lines or a communications tower in their local community).*

Safety

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations *(e.g., consider safety a positive limiting factor in scientific and technological endeavours; keep the work station uncluttered, with only appropriate laboratory materials present)*
- be aware of the direct and indirect consequences of their actions *(e.g., carefully manipulate materials, being cognizant of the risks and consequences of their actions; write safety and waste-disposal cautions into a laboratory procedure).*

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Unit D: Energy and the Environment *(Social and Environmental Contexts emphasis)*

Overview: Sustainable development requires balancing global energy demands with maintaining a viable biosphere. Students investigate and analyze the sources of renewable and nonrenewable energy for meeting global energy needs. In so doing, students explore the need for multiple perspectives, and the need to develop energy-efficient technologies for a sustainable energy future.

Focusing Questions: How can Canadians and others conserve energy and maintain quality of life? What are the benefits and costs of available nonrenewable energy sources and of developing renewable energy sources? What is our energy future?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- ☆ global energy consumption and impact on biosphere
- ☆ sources of renewable energy
- ☆ balancing energy use with sustainable development
- ☆ conversion of solar energy, fossil fuels, and wind and water power into thermal and electrical energy
- ☆ heats of formation and Hess's law
- ☆ nuclear, wind, hydro, biomass, tidal, solar, fuel cell and geothermal alternative energy technologies
- ☆ fission and fusion, CANDU reactor, nuclear change
- ☆ risk/benefit analysis for decision making on harnessing various energy sources

STS and Knowledge Outcomes

Students will:

1. Explain the need for reconciling the growth in global energy demands with maintaining a viable biosphere
   - investigate and analyze the exponential growth of global energy consumption in recent modern history
   - compare Canada's per capita energy consumption with developed and developing countries, and identify factors that affect consumption *(e.g., factors could include: economy, lifestyle, level of technology, geography, climate)*
   - apply the concept of "sustainable development" (developed in Science 20, Unit B and C), to increasing the efficient use of energy *(e.g., efficient use of energy in the home, in industry, and in transportation)*
   - explain the need for developing renewable and nonrenewable energy sources to meet increasing global energy needs
   - describe the environmental impact of developing various energy sources *(e.g., conventional and offshore oil, oil sands, wind power, biomass, hydroelectricity, coal-burning power, nuclear power, geothermal).*

2. Describe the Sun as Earth's main source of energy, and explain the functioning of technologies that convert nuclear and tidal energy into useable forms
   - compare the proportion of the ambient solar energy that creates wind, and powers the water cycle with the very small amount captured by photosynthesis as chemical potential energy

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- describe how solar energy is converted to wind and hydro power, stored as chemical potential energy by photosynthesis, and these forms of energy in turn are converted to thermal and electrical energy *(e.g., how nonrenewable energy sources, such as coal, oil and natural gas, were converted to stored chemical energy millions of years ago)*
- describe the functioning of new energy technologies, and assess the commercial potential of various renewable energy resources *(e.g., "active" and "passive" solar heating technologies, or wind turbines, or hydroelectric power, or biomass energy, or geothermal energy, or hydrogen fuel cell)*
- predict heats of combustion for different fuels, using Hess's Law (i.e., $\Delta H^\circ = \sum \Delta H^\circ_f(\text{products}) - \sum \Delta H^\circ_f(\text{reactants})$)
- investigate the efficiency of a device, using energy input/energy output data *(e.g., solar collector, photovoltaic cell, fossil fuelor biomass burner, biogas generator)*
- explain the difference between fission and fusion, and balance simple equations representing nuclear reaction to show the conservation of nucleons
  (*e.g.*, ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$, ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$, ${}^{1}_{0}n + {}^{239}_{94}Pu \rightarrow {}^{130}_{50}Sn + {}^{107}_{44}Ru + 3{}^{1}_{0}n$)
- describe and compare the types and sources of radioactive decay and resulting ionizing radiation *(e.g., alpha (α), beta (β) and gamma (γ) decay)*
- apply $E = mc^2$ to determine mass/energy changes in fission and fusion reactions, given the mass difference
- describe, in general terms, the operation of a fission reactor and the current state of fusion research *(e.g., the Canadian Deuterium Uranium Reactor [CANDU])*
- trace the relationship between nuclear energy and geothermal energy
- compare conventional; i.e., coal or oil fired, and hydroelectric, with nuclear power stations, in terms of purpose, process of energy conversions, design and function
- compare, quantitatively, the orders of magnitude of energy produced by nuclear, chemical and phase changes
- explain the source of tides in terms of Newton's law of universal gravitation–from Unit C–and the relative motions of the Sun, Moon and Earth
- describe the energy transformations involved in converting tidal energy to electrical energy, and compare tidal power to hydroelectric power *(e.g., proposal for Bay of Fundy tides; La Rance, France the only tidal generating station).*

3. Analyze the risks and benefits of various energy sources, taking into consideration a variety of perspectives to determine if the energy sources and conversion technologies will meet societal needs, protect the environment and make judicious use of natural resources
   - perform a risk/benefit analysis from a variety of perspectives, including social, cultural, environmental, ethical and economic, on an energy transformation technology *(e.g., nuclear, or geothermal, or fossil fuel, or hydroelectric, or wind, or tidal power or hydrogen cell power)*
   - assess and determine if the needs of society and of the environment are being met by the expenditure of money into research and development of new energy conversion devices and sources *(e.g., biomass, nuclear fusion, geothermal, solar heating technologies, or wind turbines)*
   - investigate and assess the need for strategies and policies to increase energy efficiency as a means of reconciling global energy demands with maintaining a viable biosphere *(e.g., co-generation, waste energy recovery, electrical load scheduling; policies to facilitate energy efficiency and increase reliance on renewable energy sources).*

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Skill Outcomes *(focus on applying science to inform decision-making processes)*

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- identify questions to investigate that arise from practical problems and issues *(e.g., "Which energy sources and technologies best balance the need for global energy demand with acceptable environmental impact?")*
- design an experiment, and identify specific variables *(e.g., compare the heat produced by various fuels)*
- state a prediction and a hypothesis based on available evidence and background information *(e.g., predict the time frame by which world oil reserves may reach near-depletion levels, based on the current rates of consumption and estimates of resources).*

Performing and Recording

Students will:

Conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information

- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data *(e.g., analyze graphs of current and projected energy consumption)*
- use library and electronic research tools to collect information on a given topic *(e.g., debate the issue: protecting the environment should have priority over economic interests; use current, reliable information sources from around the world on oil and gas reserves; demonstrate proficiency in uploading and downloading text, image, audio and video files)*
- select and integrate information from various print and electronic sources *(e.g., create multiple-link documents appropriate to the content of the particular topic, such as fuel-cell research; search government publications, and gather relevant information on sustainable development initiatives).*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible explanations

- compile and display evidence and information, by hand or using technology, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots *(e.g., select and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases or spreadsheets; present statistical data in diagrams, tables and graphs as part of a brief for a public hearing on the proposed development of an energy source in an ecologically sensitive area; analyze data charts, tables and graphs on global energy consumption in the past, present and future)*
- identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information *(e.g., assess the authority, reliability and validity of electronically-accessed information on alternative and renewable energy sources; identify and analyze a variety of factors that affect the authenticity of information derived from the mass media and electronic communication)*

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- identify new questions or problems that arise from what was learned *(e.g., "What is humanity's global energy future?", "What if nuclear fusion becomes a practical source of energy on Earth?")*
- identify and evaluate potential applications of findings *(e.g., analyze energy consumption by various sectors, such as: metallurgy, petrochemical, pulp and paper, transportation).*

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions; and receive, interpret, understand, support and respond to the ideas of others *(e.g., use appropriate communication technology to elicit feedback from others; participate in a variety of electronic group formats; prepare a visual display, explaining initiatives taken by industry to protect the environment)*
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., use advanced menu features within a word processor to accomplish a task to insert tables and energy budgets for a risk/benefit analysis, incorporating a variety of perspectives including social, cultural, environmental, ethical and economic on an energy transformation technology)*
- synthesize information from multiple sources or from complex and lengthy texts, and make inferences based on this information *(e.g., record relevant data for acknowledging sources of information, and cite sources correctly; use integrated software effectively and efficiently to reproduce work that incorporates data, graphics and text)*
- identify multiple perspectives that influence a science-related decision or issue *(e.g., consult a wide variety of sources that reflect varied viewpoints on particular topics, including social, cultural, environmental, ethical and economic strategies and perspectives; co-generation, fuel efficiency, waste energy recovery, electrical load scheduling; policies to facilitate energy efficiency and increase reliance on renewable energy sources)*
- develop, present and defend a position or course of action, based on findings *(e.g., develop an energy policy based upon the following statements: The technology needed to provide alternative sources of energy and raw materials for hydrocarbon-based products will not be adequately developed before the year 2100. By 2050, unless other actions are taken including lifestyle changes and creation of new infrastructures, Canadian crude oil supplies will decline enough to result in higher energy costs due to importation–a potential energy crisis.)*
- evaluate individual and group processes used in planning, problem solving and decision making, and completing a task *(e.g., develop a group-based policy recommendation or decision based on the above scenario).*

Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- appreciate that the applications of science and technology can raise ethical dilemmas *(e.g., use a multi-perspective approach, considering scientific, technological, economic, cultural, political, environmental and other factors when formulating conclusions, solving problems or making decisions on an energy/environmental issue; carefully research and openly discuss ethical dilemmas associated with the applications of science and technology)*

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- value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds *(e.g., recognize the contribution of science and technology to the progress of civilizations; recognize that western approaches to science are not the only ways of viewing the universe; consider the research of both men and women).*

Interest in Science

Students will be encouraged to:

- show a continuing and more informed curiosity and interest in science and science-related issues *(e.g., explore and use a variety of methods and resources to increase their own knowledge and skills; be interested in science and technology topics not directly related to their formal studies)*
- consider further studies and careers in science- and technology-related fields *(e.g., maintain interest or pursue further studies in science and careers in sustainable energy–efficiency technologies, environmental monitoring, housing design).*

Scientific Attitudes

Students will be encouraged to:

- evaluate evidence confidently, and consider alternative perspectives, ideas and explanations *(e.g., insist on evidence before accepting a new idea or explanation; critically assess their opinion of the value of science and its applications; criticize arguments in which evidence, explanations or positions do not reflect the diversity of perspectives that exist)*
- use factual information and rational explanations when analyzing and evaluating *(e.g., criticize arguments based on the faulty, incomplete or misleading use of numbers; insist that the critical assumptions behind any line of reasoning be made explicit, so that the validity of the position taken can be judged).*

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *(e.g., be attentive when others speak; seek the point of view of others, and consider a multitude of perspectives).*

Stewardship and Ethical Behaviour

Students will be encouraged to:

- have a sense of personal and shared responsibility for maintaining a sustainable environment *(e.g., assume part of the collective responsibility for the impact of humans on the environment; participate in community activities related to the preservation and judicious use of the environment and its resources; encourage their peers or members of their community to participate in a project related to sustainability)*
- project the personal, social and environmental consequences of proposed action *(e.g., consider all perspectives when addressing issues, weighing scientific, technological and ecological factors; discuss both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans)*
- want to take action for maintaining a sustainable environment *(e.g., participate in the social and political systems that influence environmental policy in their community; willingly promote actions that are not injurious to the environment; make personal decisions based on*

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responsibility toward less privileged parts of the global community and toward future generations; be critical-minded regarding the short- and long-term consequences of sustainability).

Safety

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations *(e.g., criticize a procedure, a design or materials that are not safe or that could have a negative impact on the environment; consider safety a positive limiting factor in scientific and technological endeavours)*
- be aware of the direct and indirect consequences of their actions *(e.g., carefully manipulate materials, being cognizant of the risks and consequences of their actions).*

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